(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 234 632**
A1

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 87200192.0

(51) Int. Cl.⁴: B29D 11/00 , B29C 33/56

(22) Date of filing: 09.02.87

(30) Priority: 13.02.86 NL 8600354

(43) Date of publication of application:
02.09.87 Bulletin 87/36

(84) Designated Contracting States:
DE FR GB NL

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(54) Method of manufacturing, matrix used in the method, and method of manufacturing the matrix.

(57) A method of manufacturing components such as optical components (17, 18, 21, Figure 2C) by means of a matrix which comprises a preform 12 of glass or quartz and has a skin 14 of a cured epoxy synthetic resin, matrix suitable for use in the above-mentioned method, as well as a method for the manufacture of the matrix.

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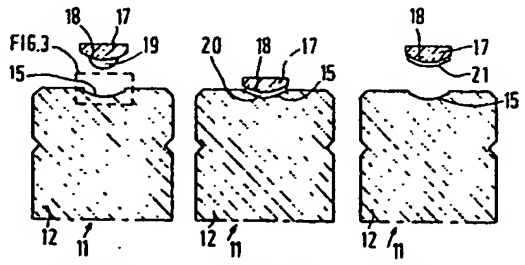

FIG.2A FIG.2B FIG.2C

Method of manufacturing, matrix used in the method, and method of manufacturing the matrix.

The invention relates to a method of manufacturing components wich comprise a supporting member of glass or a synthetic resin whose surface is provided at least partly with a synthetic coating layer having an accurately defined surface, in which a curable liquid monomer composition is provided between an accurately defined surface of a matrix and a surface of the supporting member, the composition is cured and the supporting member together with the cured synthetic resin layer bonded thereto is removed from the matrix.

This method, sometimes termed replica process, is suitable notably for the manufacture of high quality optical components such as lenses and mirrors. It concerns components having a complicated refractive surface, for example, an aspheric surface.

The matrix used in the method is usually manufactured from quartz as is described, for example, in Netherlands Patent Application No. 8301482 - (PHN 10,657), Netherlands Patent Application No. 8400868 (PHN 10,975) and British Patent Specification 1,301,551.

The curable monomer composition used in the method may be a thermal hardening resin as is mentioned in the above-mentioned British Patent Specification. A light-curable, for example UV light-curable, monomer composition is preferably used, for example, a mixture of acrylates and a photo-initiator. Such a monomer composition is mentioned in the above Netherlands Patent Applications both in the name of the Applicants.

A matrix of glass or quartz presents the advantage of a good non-deformability, great hardness and a very strong resistance to chemical attack, for example, oxidation. An advantage which is very important for practical purposes is that the monomer composition is exposed via the transparant matrix and can be cross-linked (cured). The use of a stainless steel matrix as described in United States Patent Specification 4,432,832 does not have this important advantage. Moreover, a stainless steel matrix is by far less resistant to chemical attack.

A disadvantage of the use of a matrix of glass or quartz is that it has not proved possible to grind the glass or quartz surface to the described accuracy in a reproducible manner. All the matrices used in a mass production process mutually have slightly different refractive surfaces. This means that the components manufactured by means of such matrices do not have a uniform reproducible quality.

It is the object of the invention to provide a method in which the manufactured components have the same uniform reproducible quality. Another object is to use in the method matrices which can be produced in large numbers, rapidly, cheaply and especially with great uniform accuracy.

These objects are achieved by means of a method of the type mentioned in the opening paragraph which is characterized in that a matrix is used which has a layered structure in which the matrix has a preform of glass or quartz which at the area where it contacts the above-mentioned monomer composition comprises a skin of a cured epoxy synthetic resin whose surface is accurately defined and is the negative of the desired surface of the manufactured component.

The cured epoxy synthetic resin is obtained by heating or exposing, for example, to UV light, an epoxy resin to which a catalyst or photo-initiator has been added. Light-curable or heat-curable epoxy resins are sufficiently known from literature and are commercially available. The name epoxy resin is to be understood to be a monomer, dimer, oligomer or polymer with one or more functional epoxy groups. These resins are obtained, for example, by causing bisphenols, for example 4,4'-isopropylidenediphenol (bisphenol-A) or phenolformaldehyde resins of low molecular weight (Novolak resins) to react with epichlorohydrin. The light curable epoxy resins comprise a photo initiator. A suitable photo initiator is an aromatic halonium salt, for example, diphenyliodonium hexafluoroarsenate. For UV light-curable epoxy resins reference is made to be published Netherlands Patent Application No. 7909257.

In a favourable embodiment of the method according to the invention a matrix is used whose preform manufactured from glass or quartz has a refractive surface which is concave spherical and has a layer of a cross-linked epoxy synthetic resin in which the surface of the layer epoxy synthetic resin remote from the preform is concave aspherical.

The invention also relates to a matrix which is suitable for use in the above-described method and which is characterized in that the matrix has a layered structure, a preform of glass or quartz having a refractive surface and a layer of a cross-linked epoxy synthetic resin provided on said refractive surface, the surface of the layer of the epoxy synthetic resin remote from the preform having an optically accurately defined shape.

In a favourable embodiment of the matrix according to the invention the preform of glass or quartz has a concave spherical surface which has a layer of a cross-linked epoxy synthetic resin, the surface of the layer of the epoxy synthetic resin remote from the preform being concave aspheric.

In a further favourable embodiment of the matrix the layer of cured epoxy synthetic resin comprises a thin layer of SiO_2 which optionally comprises a mould release agent. A suitable mould release agent is, for example, an Ag-alkylmercaptan, for example Ag-hexadecylmercaptan.

A great many components can be manufactured according to the above-described replica process in particular by means of a matrix according to the last-mentioned embodiment, in particular a matrix having a supporting member of quartz which at the refractive surface has a layer of a cured epoxy synthetic resin and thereon a layer of SiO_2 and a mould release agent. Interaction between the curable monomer composition, for example, a composition of UV light-curable acrylate on the one hand and the combined layers of cured epoxy synthetic resin and SiO_2 on the other hand does not take place.

The invention furthermore relates to a method of manufacturing the above-described matrix. The method according to the invention is characterized in that an accurately defined surface of a metal mould is provided against a refractive surface of a preform of glass or quartz in which a layer of a liquid, light-or heat-cross-linkable epoxy resin is provided between the two said surfaces, the layer of the liquid epoxy resin is cross-linked and the preform with the layer of the cross-linked epoxy synthetic resin bonded thereto whose surface is the negative of that of the mould is removed.

The metal mould is preferably manufactured from aluminium, copper or brass. These metals can very readily be machined with high precision. By means of a precision maching operation, such as turning, the metal mould can be provided with a very accurately defined surface, in particular an aspherical surface. Of such a mould many matrices can be manufactured according to the above method in which each matrix has a fully identical reproducible surface which is the exact negative of the surface of the metal mould. In comparison with the known process of manufacturing quartz matrices in which the quartz surface is machined by a cumbersome grinding and polishing process to the desired accurate shape, the process according to the invention has the advantage that the resulting matrices have a more accurate and in particualr more uniform surface. Another important advantage is that the matrices can be manufactured considerably more rapidly and cheaply by a great saving of processing time.

The metal mould, for example a copper mould, may be provided with a mould release layer and the refractive surface of the preform of glass or quartz may be provided with a bonding layer. A suitable mould release layer is, for example, a layer of an alkylmercaptan. An example of a bonding layer for an epoxy synthetic resin is a layer of a -glycidoxypropyl trimethoxysilane. This bonding layer is cured together with the liquid epoxy resin and is cross-linked to the epoxy resin.

The invention will be described in greater detail with reference to the drawing, in which

Figure 1 is a diagrammatic cross-sectional view of a method of manufacturing a matrix, and

Figure 2 is a diagrammatic cross-sectional view of a method of manufacturing components by means of the matrix obtained by using the method shown in Figure 1,

Reference numeral 1 in Figure 1 denotes a mould manufactured from aluminium and having an aspheric surface 2 which is very accurately profiled by means of a mechanical precision working process, in particular by means of turning. The aspherical surface 2 has a mould release layer not shown. Reference numeral 3 denotes a preform of quartz. This preform has a pre-processed refractive surface 4 which has a concave spherical shape. Refractive surface 4 of preform 3 comprises a bonding layer not shown. A small quantity of a UV light-curable epoxy resin 5 is provided on the refractive surface 4 and has the following composition:

95 % by weight of diglycidyl ether of bisphenol A - (tradename DOW 332)

4.75 % by weight of diphenyliodonium hexafluoroarsenate (photo initiator)

0.25 % by weight of anthracene (sensitizer).

Mould 1 is positioned accurately relative to preform 3, for example, by means of a V-block construction. Mould 1 with aspherical surface 2 is moved towards the spherical surface 4 of preform 3. The final position is shown in Figure 1B. The liquid epoxy resin has spread between the surfaces 2 and 4, a resin layer 6 being formed. Said resin layer is exposed to UV light via the transparent preform 3 and is cured. The mould 1 is then served from the preform 3. this situation is shown in Figure 1C. The cured epoxy layer 7 is bonded to preform 3 and together with preform 3 constitutes the matrix 8. The surface 9 of the cured epoxy layer 7 remote from preform 3 is the negative of the aspherical surface 2 of mould 1. During curing of the epoxy resin some shrinkage will occur. In the manufacture of the aspherical surface 2 of mould 1 this shrinkage has been taken into account. So the surface 2 has been corrected for such a shrinkage. It is also possible, after severing mould 1 and matrix 8, to repeat the above-described procedure

by means of a smaller quantity of the curable epoxy resin so that a multiple layer of cured epoxy is provided on preform 3 and herewith the shrinkage deviation is restricted to a very low level. Finally, a layer of SiO_2 in a thickness of, for example, 100 nm is vapour-deposited or sputtered on epoxy layer 9 of matrix 10 and a mould release layer of, for example, Ag-hexadecylmercaptan is provided thereon. In the above-described manner a great many fully identical matrices can be manufactured rapidly, cheaply and with great accuracy by means of one mould. The matrices thus manufactured are used in the manufacture of, for example, an optical component as is shown in Figure 2.

Reference numeral 11 in Figure 2A and Figure 3 denotes a matrix which comprises a preform 12 of quartz. Preform 12 has a concave spherical surface 18 which is covered by a layer 14 of cured synthetic resin (see Figure 3). Layer 14 has an optically accurate aspherical surface 15 which is coated by a layer 16 of vapour deposited or sputtered SiO_2. A mould release layer of Ag mercaptan, not shown, is provided on layer 16. Reference numeral 17 denotes a quartz supporting member having a spherical convex refractive surface 18 which is provided with a bonding agent γ-methacryloxypropyl trichlorosilane not shown. A small quantity of a UV light curable liquid lacquer 19 is provided on surface 18 in the following composition:

96 % by weight of ethoxylated bisphenol-A dimethacrylate (trade name Diacryl)

4 % by weight of α, α'-dimethoxyphenylacetopherone (photo-initiator, tradename Irgacure)

Supporting member 17 with lacquer deposit 19 is pressed against the aspherical surface 15 of matrix 11, lacquer deposit 19 spreading between surfaces 15 and 18. Herewith the situation shown in Figure 2B is reached. The lacquer has spread, a lacquer layer 20 being formed. The lacquer layer 20 is exposed to UV light and the supporting member 17 is then removed from the matrix 11. This situation is shown in Figure 2C. The supporting member 17 comprises at its surface 18 a layer of cured lacquer the surface 21 of which is aspherical and is the negative of the aspherical surface of matrix 11.

Claims

1. A method of manufacturing components which comprise a supporting member of glass or a synthetic resin whose surface is provided at least partly with a synthetic resin coating layer having an accurately defined surface, in which a curable liquid monomer composition is provided between an accurately defined surface of a matrix and a surface of the supporting member, the composition is cured and the supporting member together with the cured synthetic resin layer bonded thereto is removed from the matrix, characterized in that a matrix is used which has a layered structure in which the matrix comprises a preform of glass or quartz which at the area where it contacts the above-mentioned monomer composition has a skin of a cured epoxy synthetic resin the surface of which is accurately defined and is the negative of the desired surface of the manufactured component.

2. A method as claimed in Claim 1, characterized in that a matrix is used the preform of which of glass or quartz has a refractive surface which is concave spherical and has a layer of a cross-linked epoxy synthetic resin in which the surface of the layer of epoxy synthetic resin remote from the preform is concave aspherical.

3. A matrix suitable for use in the method as claimed in Claim 1 or 2, characterized in that the matrix has a layered structure, a preform of glass or quartz having a refractive surface and a layer of a cross-linked epoxy synthetic resin provided on said refractive surface, the surface of the layer of the epoxy synthetic resin remote from the preform having an optically accurately defined shape.

4. A matrix as claimed in Claim 3, characterized in that the preform of glass or quartz has a concave spherical refractive surface which has a layer of a cross-linked epoxy synthetic resin, the surface of the layer of epoxy synthetic resin remote from the preform being concave aspherical.

5. A matrix as claimed in Claim 3 or 4, characterized in that the layer of a cross-linked epoxy synthetic resin comprises a layer of SiO_2 which optionally comprises a mould release agent.

6. A method of manufacturing a matrix as claimed in Claim 3, 4 or 5, characterized in that an accurately defined surface of a metal mould is provided against a refractive surface of a preform of glass or quartz in which a layer of a liquid, light- or heat-cross-linkable epoxy resin is provided between the two said surfaces, the layer of the liquid epoxy resin is cross-linked and the preform with the layer of the cross-linked epoxy synthetic resin bonded thereto whose surface is the negative of that of the mould is removed.

7. A method as claimed in Claim 6, characterized in that the accurately defined surface of the metal mould comprises a mould release layer and the refractive surface of the preform of glass or quartz comprises a bonding layer.

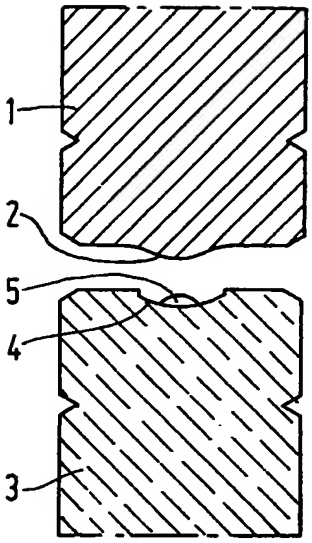

FIG.1A

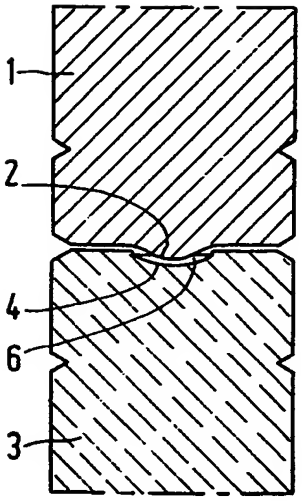

FIG.1B

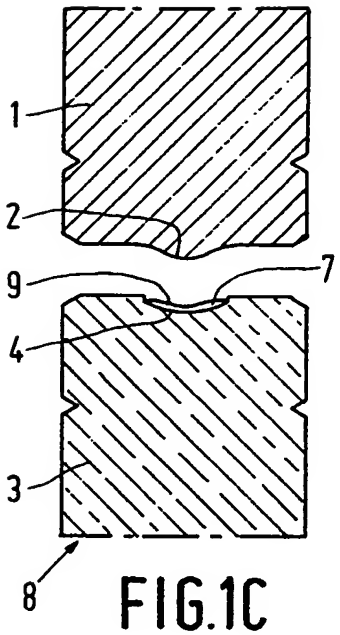

FIG.1C

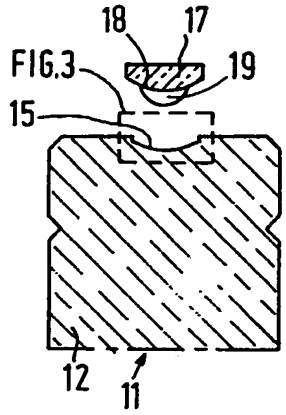

FIG.2A

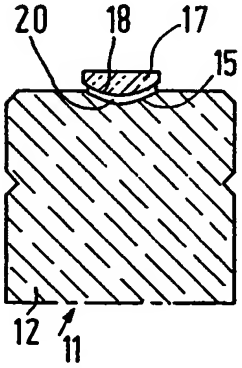

FIG.2B

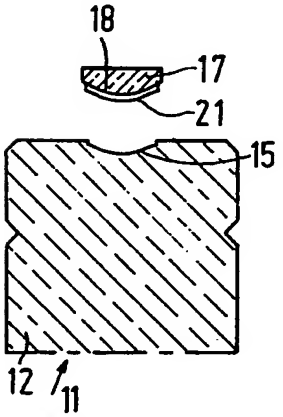

FIG.2C

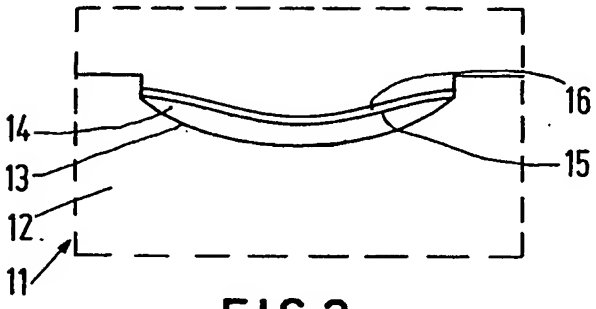

FIG.3

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 87 20 0192

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	EP-A-0 014 783 (PHILIPS) * Claims; page 11, line 6 - page 12, line 33; figures *	1-7	B 29 D 11/00 B 29 C 33/56
A	FR-A-2 148 557 (PHILIPS) * Claims; figures *	1-7	
A	FR-A-2 029 642 (BASF) * Claim 2 *	1-7	
A	FR-A-1 506 209 (BASF) * Abstract; page 1, column 2, last paragraph *	1-7	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

B 29 C
B 29 D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	18-05-1987	VANHECKE H.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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